along the back side **124** of enclosure **120**. In an alternative embodiment, heated air **119** may be exhausted along the side surfaces of the enclosure. In any event, the air duct exhaust ports should be positioned along an external wall of the computer casing so that the heated air is directed out of enclosure **120**. The heated air **119** should also be directed away from the user. A heat pipe **112** provides a low resistance thermal path from an integrated circuit package **116** to heat exchanger **110** via a conductive plate **115**. Alternatively, heat pipe **112** may be bonded directly to package **116** with the use of a thermal adhesive. FIG. **6B** shows the back side **124** of computer enclosure **120**. Recesses **126** and **128** are formed within the computer casing and within the lower edge of the display panel **121**, respectively. The recesses ensure that an adequate air flow path is available to the heat exchanger air duct inlet **129** when the computer display lid **121** is in a closed position.

FIG. 7 illustrates yet another manner of integrating the cooling system of the present invention into a portable computer system enclosure **140**. In the embodiment of FIG. **7**, heat exchanger **130** is positioned such that cool air **138** is directed into the heat exchanger air duct along a bottom and back surface of the computer casing. An air channel **135** is provided along the bottom surface of the computer to provide an air flow path into the heat exchanger when the computer is resting on a table **150** or other solid surface. The computer may also include a fluted bottom to direct air flow to the heat exchanger air duct intake. A heat pipe **132** thermally couples heat exchanger **130** to an integrated circuit package **136** via a thermally conductive mating plate **137**. Heated air **139** is directed away from the computer system enclosure via air duct exhaust ports that are preferably positioned flush along the back side **142** of the computer system enclosure **140**. It is important to note that FIGS. **6A**, **6B** and **7** are illustrative of only two of many possible cooling system arrangements. For example, the heat exchanger air duct intake may be positioned along a side of the computer system enclosure, or at other points along the top or bottom surfaces of the enclosure. It is important, however, to place the air intake and exhaust ports in positions to preclude blocking of the air flows into and out of the heat exchanger. It is also preferable to place the air intake port at a location that will provide the coolest possible air flow into the heat exchanger. In this manner, a maximum achievable heat transfer is established across the heat exchanger.

The compact design, thin construction and high efficient cooling method of the present invention provides designers of small form factor and thin profile electronic devices a high degree of versatility as to the placement of the cooling system components within the electronic device enclosure. As mentioned above, the air duct intake may be positioned along the top, bottom or side exterior surfaces of an enclosure casing. In addition, a heat generating component from which heat is to be removed can be located virtually anywhere within the electronic device enclosure via a heat pipe or other low thermal resistance heat path.

In the foregoing description a cooling system has been described wherein an axial flow fan directs air through the heat exchanger assembly. It should be understood, however, that the air generating device of the present invention may include any of a number of devices and configurations. For example, in one implementation, the present invention may include the use of a fully embedded radial or axial flow fan. FIG. 8 illustrates another manner of implementing the present invention. In the embodiment of FIG. 8, a resonant cantilever vibrator **92** is used to generate an air flow through the air duct of heat exchanger **90**. The resonant cantilever vibrator **92** comprises a piezoelectric actuator **94** having cantilever members **96a** and **96b** attached to and positioned along opposite sides of the actuator. When a voltage is applied to actuator **94**, cantilever members **96a** and **96b** oscillate to produce air flow streams **102** and **104**. Air flow streams **102** and **104** pass through the heat exchanger air duct and are exhausted adjacent opposite ends of the heat exchanger.

Thus, an improved cooling system for small form factor and thin profile electronic devices has been described. Although the present invention has been described particularly with reference to FIGS. 1A through 8, it is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the present invention. For example, the size and shape of the heat exchanger, air duct, fins, intake and exhaust ports may be altered. Materials other than those described that possess the proper heat transfer and weight characteristics may also be used.

What is claimed is:

1. An apparatus removing heat from a heat generating component, said apparatus comprising:

- a heat pipe comprising an evaporator portion and a condenser portion, said heat generating component being thermally coupled to said evaporator portion;
- an air duct comprising a housing having internal fins, said air duct directing an air flow from an inlet port located near the center of said air duct to first and second exit ports located at opposite end portions of said air duct, said condenser portion of said heat pipe being attached to said housing; and
- an air flow generator coupled to said inlet port for producing said air flow.

2. The apparatus of claim 1 wherein said heat generating component comprises an integrated circuit.

3. The apparatus of claim 1 wherein said housing comprises a first plate and a second plate having respective first and second internal surfaces, said first internal surface having a first array of protruding members that constitute said internal fins.

4. The apparatus of claim 1 wherein said housing comprises a first plate and a second plate having respective first and second internal surfaces, said first internal surface having a first array of protruding members, said second internal surface having a second array of protruding members wherein said first and second array of protruding members constitute said internal fins.

5. The apparatus of claim 1 wherein said housing comprises a material having a high thermal conductivity.

6. The apparatus of claim 1 wherein said housing comprises aluminum.

7. The apparatus of claim 1 wherein said air flow generator comprises a fan.

8. The apparatus of claim 1 wherein said air flow generator comprises a resonate cantilever vibrator.

9. An apparatus cooling an integrated circuit package assembly located within a portable computer chassis, said apparatus comprising:

- a heat exchanger comprising:
  - an air duct having a thin cross-section relative to the width of said duct, said air duct comprising a housing having facing first and second major internal surfaces and an array of fins disposed between said first and second surfaces, said housing further comprising an inlet port disposed at or near a center portion of

said air duct and first and second exit ports disposed at respective opposite first and second end portions of said duct; and

an air flow generator coupled to said inlet port for producing a first and a second air flow, said first air flow being directed from said inlet port to said first exit port, said second air flow being directed from said inlet port to said second exit port;

a heat pipe having an evaporator portion and a condenser portion, said integrated circuit package being thermally coupled to said evaporator portion; said condenser portion being coupled to said housing of said air duct.

10. The apparatus of claim **9** wherein said fins comprise integrally formed protruding members along said first internal surface.

11. The apparatus of claim **9** wherein said fins comprise a first and second array of protuberances integrally formed along said first and second internal surfaces, respectively.

12. The apparatus of claim **9** wherein said housing comprises a material having a high thermal conductivity.

13. The apparatus of claim **9** wherein said housing comprises aluminum.

14. The apparatus of claim **9** wherein said air flow generator comprises a fan.

15. The apparatus of claim **9** wherein said air flow generator comprises a resonate cantilever vibrator.

16. A portable computer comprising:

an enclosure having an air duct comprising a housing having internal fins, said air duct directing an air flow from an inlet port located near the center of said air duct to first and second exit ports located adjacent opposite end portions of said air duct, said air duct having a substantially equal width as said enclosure, said enclosure comprising first, second and third sides;

an air flow generator coupled to said inlet port for producing said air flow; and

heat transfer means thermally coupling a heat generating component located within said enclosure to said air duct housing.

17. The portable computer of claim **16** wherein said first and second exit ports face said first side such that said air flow leaves said enclosure from said first side.

18. The portable computer of claim **16** wherein said first and second exit ports face said second and third sides, respectively, such that said air flow leaves said enclosure from said second and third sides.

19. A method for cooling a heat generating component located within an enclosed compartment, said method comprising the steps of:

thermally coupling said heat generating component to the housing of an air duct having a thin cross-section relative to the width of said air duct, including the steps of thermally coupling said component to an evaporator portion of a heat pipe, and thermally coupling a condenser portion of said heat pipe to said air duct housing; and

producing an air flow through said air duct by directing air external to said compartment into an inlet port located at or near the center of said air duct and splitting said air flow into a first air flow and a second air flow, said first air flow being directed to a first exit port located at a first end portion of said air duct, said second air flow being directed to a second exit port located at a second end portion of said air duct.

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